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Application of Biourin and Mycorrhizal Fertilizers on the Dynamics of Available P, P Uptake, and Shallot (*Allium ascalonicum* L.) Yield in Vertisols

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ABSTRACT

The aim of this study was to evaluate the effect of application of biourin fertilizer and Mycorrhizal Vesicles Arbuscula (MVA) dosage on P dynamics, P uptake and yield of shallots in vertisols. This study was designed with a factorial design pattern on the basis of a randomized block design (RBD). The treatment tested was the concentration of biourin (B), with four levels: B10: Concentration of 10 ml.l-1 water, B20: Concentration of 20 ml.l-1 water, B30: Concentration of 30 ml.l-1 of water and B40: Concentration 40 ml.l-1 of water. The second treatment was MVA dose with four levels, namely: M0: Without MVA, M10:10 g.plant-1, M20: 20 g.plant-1 and M30: 30 g.plant-1. The results showed that the biourin concentration of 40 ml.l-1 of water and the MVA dose of 30 g.plant-1 significantly affected the dynamics of available P in Vertisol. The application of biourin at a concentration of 30 ml.l-1 water showed a P absorption of 15.07% and increased shallot yields by 41.07%. The best application of MVA biofertilizer in vertisols was achieved at a dose of 30 g.plant-1, able to increase plant nutrient P uptake by 152% and increase shallot yield by 72.38% from without MVA.

1. INTRODUCTION

Vertisol is a type of sedimentary soil that is widely used for agriculture. The potential for vertisol soils in Indonesia reaches 2.1 million hectares and 9.43% (0.198 million ha) are spread over the East Nusa Tenggara (NTT) region. Vertisol soil has many weaknesses, including physically it is relatively difficult to cultivate because it has a clay content of >60% (Prasetyo, 2007), low fertility with C-organic content (<2%), available K (0.10 me/100 g soil) and low available P (12.60 ppm), and medium N-total (0.24%) (Sudadi *et al*., 2007).

In general, vertisol soils in the Timor NTT region have high total soil P levels, but available P and very low organic matter content (Matheus & Kantur, 2022). Most of the phosphorus provided through fertilization will be fixed by Ca in soils which react neutral to alkaline. Therefore, only 10-20% of the P that is given to the soil can be used by plants (Farida & Chozin, 2015). Application of inorganic fertilizers to the soil will become more available and increase the response of plants to nutrients, if accompanied by the application of soil amendments such as fertilizers organic or biochar (Lian, 1993; Jaenudin *et al*., 2021; Yoanma *et al*., 2022).

In connection with the problem of low P availability in vertisols, a practical effort that can be done is to use microbial-based fertilizers. One of them is biourin liquid organic fertilizer enriched with indigenous microbes (Matheus & Djaelani, 2021). Biourin is a type of liquid organic fertilizer made from cow urine. The results of a study on beef biourin products, showed that beef biourin enriched with indigenous microbes significantly increased shallot yields (an average of 15.92 tons/ha) or increased shallot yields of 53.52% from treatment without biourin (Matheus & Djaelani, 2021).

Generally, organic fertilizers, both in solid and liquid form, are slow release, meaning that the nutrients in the fertilizer are released slowly and continuously over a certain period of time, so that the nutrients are not immediately available to plants. Therefore, to help increase the availability and absorption of nutrients by plants can be applied mycorrhizal fungi (vesicula-arbuscular mycorrhiza). Vesicular-arbuscular mycorrhiza (MVA) is a type of fungus that is capable of symbiotic on plant roots, to increase plant resistance and increase nutrient uptake, especially phosphorus (P), water absorption and increase drought resistance and increase soil microbial activity (Puspita *et al*., 2013; Farida & Chozin, 2015). In addition to activating nutrient uptake by plants, the presence of MVA can suppress "soil-borne disease", speed up the composting process, improve soil structure, and produce active substances that can increase plant growth (Musafa *et al*., 2017; Hazra *et al*., 2020).

Based on the explanation above, this study aims to determine the effect of cattle biourin concentration and mycorrhizal dose (MVA) on soil P dynamics, P nutrient uptake and shallot yields in Vertisols.

2. MATERIALS AND METHODS

This research was conducted on farmer's land in Noelbaki Village, Kupang Tengah District, Kupang Regency, East Nusa Tenggara. The research location was located at coordinates 10°12'63.74" South Latitude and 123°71' 38.67" East Longitude. The field research took place from May to August 2022. Meanwhile, measurements of soil quality and plant nutrient uptake were carried out at the Soil Laboratory, Faculty of Agriculture, Udayana University-Bali.

The materials used were experimental land classified the vertisol soil, Bima local variety of shallot seeds, organic fertilizer in form of biourin water, arbuscular vesicle mycorrhizal (MVA) inoculant obtained from the Balai Penelitian Tanaman Obat dan Aromatik (BALITTRO, Bogor), inorganic fertilizer in the form of SP-36, plot nameplate and sample pouch. The tools used in this study were equipment for soil preparatio, scales, and laboratory equipment for soil and plant analysis.

2.1. Experimental Design

This study used an experimental method which was designed in a factorial pattern with a basic randomized block design (RBD). The treatment tested was the concentration of cattle biourin fertilizer (B) with four levels: B10 (concentration of 10 ml/L water), B20 (concentration of 20 ml/L water), B30 (concentration of 30 ml/L water), and B40 (concentration 40 ml/L water). The second factor was the biological fertilizer treatment of the arbuscular vesicle mycorrhizal type (MVA) with four levels, namely: M0 (without MVA), M10 (10 g/plant), M20 (20 g/plant), and M30 (30 g/plant). Each treatment combination was repeated 3 times so that there were 48 experimental units. As an independent variable, in this study SP-36 fertilizer was given as a source of phosphate at a dose of 75 kg/ha.

2.2. Experimental Execution

The experimental land is dry land which was cultivated or planted with seasonal food crops every season. The type of soil for this experiment is Vertisols. The results of soil analysis at the beginning of the experiment had characteristics, such as: clay content 72.74% (loamy clay), 1.56% C-organic (very low), pH 7.65 (slightly alkaline), 0.16% total N (very low), and available P of 5.26 ppm (low). The experimental land was formed into planting beds according to the number of experimental units. The size of the planting bed is 2 m x 1.20 m with a bed height of 30 cm. The distance between treatment plots was 50 cm, the distance between block repetitions was 100 cm. Fertilizer SP-36 (source of P) as an independent variable was given to all experimental units at a dose of 75 kg/ha. SP-36 fertilizer was applied one day before planting shallots, by furrowing method. MVA biological fertilizer treatment was given according to the dose, namely: 10, 20, 30, and 40 g/plant. The application was done simultaneously with the planting of shallot seeds, by sowing in each planting hole. The treatment of cattle biourin fertilizer was applied according to the concentration of biourin (10, 20, 30 and 40 ml/L water). The frequency of biourin application was carried out 3 times when the plants were 2, 4 and 6 weeks after planting (WAP). The application of biourin was carried out by means of vertigation, namely biourin fertilizer was mixed in the irrigation water according to the dosage treatment. Maintenance of experimental plants was carried out through watering, weed control, and pest control as required. Observation of plants to measure nutrient uptake was carried out destructively in the active vegetative phase. Observation of soil properties and yield of shallots were carried out after harvesting shallots. Harvesting was carried out after the plants entered harvest age, which was 90 days after planting (DAP).

2.3. Observational Variables

Observations on soil chemical properties were carried out only at available P levels, which were measured monthly to determine the dynamics of P in the soil. Soil samples for each experimental unit were taken when the plants were 1, 2, and 3 month after planting (MAP) at a depth of 0-20 cm. Prior to chemical analysis, the soil samples were air-dried, ground, and sieved. Observations on shallot plants include: degree of root infection, nutrient P uptake, plant dry weight, and shallot yield. For plant nutrient analysis, plant samples were taken during the maximum vegetative phase (60 days old), which was carried out destructively. P nutrient uptake is the amount of P nutrient that enters plant tissue which is calculated by the formula:

$$P\ absorption = nutrient\ content\ (\%) * plant\ dry\ weight\ (g) \quad (1)$$

MVA infection analysis was carried out on the roots of shallot plants in the maximum vegetative phase. The percentage of mycorrhizal infections was calculated from the number of infected roots divided by the total number of root pieces observed (Brundrett *et al*., 1996).

2.4. Data analysis

Prior to statistical tests, the data from the research results were tested for normality and homogeneity. If the data is declared normal and homogeneous, then proceed with an analysis of variance to test the value of differences between treatments. If there is a significant difference between treatments, then the mean difference test is continued with the least significant difference model (LSD) at an error level of 5% to compare the effect of treatments with different means. All of these tests use the SPSS-25 application.

3. RESULTS AND DISCUSSION

3.1. Vertisol soil properties

The results of the initial soil analysis before the experiment showed that the soil pH was slightly alkaline, the available P and organic C content in the Vertisol soil were 0.04 ppm P2O5 and 1.80% C, respectively. The results of the analysis of soil properties and organic fertilizers of liquid biourin is presented in Table 1.

Table 1. Characteristic of Vertisol soil at the study site and biourin fertilizer

No	Chemical properties	Vertisol Soil		Liquid Cattle Biourin	
		Value	Rank	Value	Rank
1	pH	7.72	Slightly alkaline	6.77	Netral
2	P-available (ppm)	6.55	Low	91.39	High
3	C-organic (%)	1.85	Low	6.97	High
4	N (%)	0.2	Low	3.08	High
5	CEC (me/100 g)	9.84	Low	-	-

Soils with very low available P conditions can result in disturbed plant growth if there is no addition of P from outside in the form of P fertilizers. CEC analysis results also showed low results. This indicates that the soil has undergone further weathering resulting in low soil fertility and is supported by the results of soil pH and available P analysis. The low CEC value causes cations in the soil in the form of K+, NH4+, Ca and others to be easily leached as a result of poor soil nutrients.

3.2. Dynamics of P-available

The results of the ANOVA concluded that the application of biourin and MVA biological fertilizers had a significant effect ($P<0.05$) on the P uptake of shallot plants, but the interaction between the two factors had no significant effect. Single factor analysis showed that the treatment of biourin concentrations and MVA biofertilizer doses significantly affected the dynamics of P-available at 1, 2 and 3 MAP. The results of available-P dynamics analysis, which is carried out every MAP for each single factor treatment are presented in Figures 1 and 2.

Figures 1 and 2 show the dynamics of soil P-available during the plant growth period at various biourin concentration levels and MVA biofertilizer doses. In general, the treatment of biourin concentrations (Figure 1) increased the dynamics of P-available at various levels of biourin concentrations during the observation period. Increasing the concentration of biourin fertilizer to 30 ml/L water and 40 ml/L water significantly affected the dynamics of P-available up to 2 MAP and decreased at 3 MAP. The dynamics of P-available occur due to the influence of biourin fertilizers.

In addition to containing nutrients, they also contain functional microbes capable of playing a role in degrading organic matter and increasing the capacity of soil cation exchange, so that P derived from fertilizers and soil P that is not available can become available. The P nutrient in Vertisol soil will be bound by Ca in the form of hydroxy phosphate so that it will form insoluble compounds, resulting in P that is not available to plants (Jaenudin *et al*., 2021; Hazra *et al*., 2021). Ca in the soil solution becomes inactive when it interacts with humic materials so that phosphate embedding can be reduced, thereby increasing the availability of P in the soil (Stevenson, 1994). Functional groups of organic acids play a role in blocking the surface of aluminum hydroxide which is reactive to phosphate by a specific group of organic anoin, thereby eliminating the effect of specific surface binding to phosphate (Moshi *et al*., 1974).

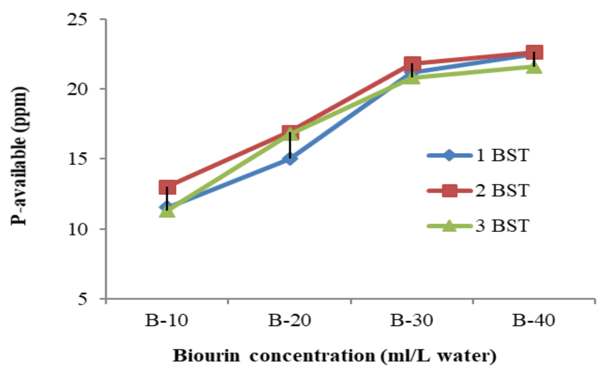

Figure 1. Effect of biourin concentration treatment on the dynamics of P-available during shallot planting in Vertisol

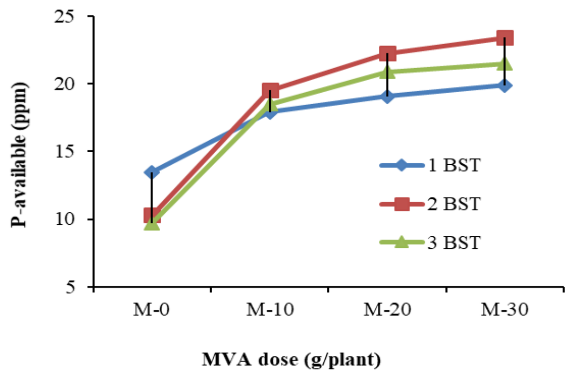

Figure 2. Effect of MVA dose treatment on the dynamics of P-available during shallot planting in Vertisol

The similar thing was also seen in the MVA biological fertilizer dose treatment. Figure 2 indicates the dynamics of P-available during the plant growth period. The increase in the MVA level to 30 g/plant significantly affected the dynamics of soil P-available, there was an increase up to 2 MAP and then decreased at 3 MAP. In the third month, P-available decreased in both the biourin treatment (Figure 1) and the MVA treatment (Figure 2) compared to the first and second months. The dynamics of P-available in vertisols also occur in MVA applications due to the role of mycorrhizal fungi applied to shallot plants. This is in line with the research of Mustafa *et al*. (2017) which stated that giving a dose of 30 arbuscular mycorrhizal spores and fluorensces bacteria significantly increased P uptake by 107% (24.40 ppm) compared to no MVA.

3.3. P Uptake by Plant

The results of ANOVA disclosed that the application of biourin fertilizer and MVA biofertilizer had a very significant effect ($P<0.01$) on the P uptake of shallot plants, but the interaction between the two factors had no significant effect. The BNT test results in Table 2 show that there is a significant difference between each single factor treatment. Increasing the biourin concentration markedly increased plant P uptake. An increase in the concentration of cattle biourin (40 ml/L water) showed an increase in P uptake, amounting to 3.28 g/100 g plant and was not significantly different from a concentration of 30 ml/L water. Increased plant P uptake at higher biourin concentrations, because cattle biourin fertilizer, apart from supplying nutrients to plants, also contains functional microbes that are capable of degrading organic matter in the soil so that it can increase the CEC of the soil. By increasing the CEC, P which was previously unavailable becomes available so that it is easily absorbed by plant roots. This is in line with the research of Simanungkalit *et al*. (2006) who concluded that organic fertilizers, both in solid and liquid form, apart from supplying nutrients in the soil, can also act as a soil enhancer to increase the availability of nutrients in the soil. Organic fertilizers are also rich in functional microbes which have an important role in the soil (Stevenson, 1994).

Table 2. Results of the LSD test on the average P uptake of shallots due to a single factor on cattle biourin concentrations and MVA biofertilizer doses

Treatment	P uptake (g/100 g plant)
Biourin concentration (ml/L water):	
10	2.72 ± 2.47 [c]
20	2.91 ± 2.67 [b]
30	3.13 ± 2.88 [a]
40	3.28 ± 3.03 [a]
MVA dose (g/plant):	
0	1.63 ± 0.53 [d]
10	2.64 ± 1.54 [c]
20	3.65 ± 2.55 [b]
30	4.11 ± 3.01 [a]

Note: Numbers followed by the same letters in the same column are not significantly different according to the LSD test at the 5% level. The number followed by ± is the standard deviation.

The same thing was also seen in the treatment of MVA biological fertilizer doses, which showed differences in plant P uptake. The results of this study showed that the higher the MVA dose, significantly increased plant P uptake. Treatment of MVA biological fertilizer at a dose of 30 g/plant significantly increased P absorption by 4.11 g/100 g plant (152% increase in absorption from control) and was significantly different from other treatments. Treatment without MVA showed low plant P uptake, amounting to 1.63 g/100 g plant. The high uptake of plant P that occurred at high MVA doses was due to the role of mycorrhiza which was quite effective in helping to release P from the soil micelle bonds. In general, vertisols have low P availability, so that the application function of MVA is more obvious.

The results of this study are in line with Rahman *et al*. (2019) who stated that the application of arbucular mycorrhizae was able to increase nutrient P uptake and fertilization efficiency in shallot plants. Mycorrhizal plants have the ability to absorb P and other nutrients such as N, K and Mg in the depletion zone around the roots and their roots have external hyphae that can expand the absorption surface of the roots (Hartoyo *et al*., 2011). The research results of Matheus & Kantur (2022) stated that the application of MVA from organic sources of *Mucuna* and *Crotolaria* significantly increased the P uptake of corn plants respectively by 27.83% and 28.85% as compared to no organic matter. In conditions of low P availability, the application function of arbuscular mycorrhizae becomes more visible. Whereas in conditions of sufficient P availability, the additional dose of P fertilizer will increase the dissolved P content in the soil.

According to Orcutt & Nielsen (2000), MVA is able to increase nutrient uptake in the following ways: (1) expanding the root surface in the presence of an external hyphal network which is much finer in size compared to root hairs so that it can penetrate soil pores, (2) accelerating the movement of P goes to the roots through increasing the affinity of P to the roots thereby reducing the occurrence of depletion areas, (3) changing the rhizosphere environment chemically through the release of organic acids and increasing phosphatase activity, and (4) increasing the production of phytohormones which can change the phenotype of the roots thereby increasing the total nutrient absorption capacity. .

The increase in plant P uptake occurred due to an increase in the MVA external hyphae network which infects plant roots and expands the root absorption area in absorbing water and nutrients. In addition, the very fine size of the hyphae in the root hairs allows the hyphae to infiltrate the finest soil pores so that the hyphae can absorb water in low groundwater stress conditions. Mycorrhizal plants will absorb more water, making it easier to increase nutrient uptake by plant roots, such as N, P, and K nutrients (Kilham, 1994). Utomo *et al.* (2017) reported that plants infected with MVA were able to absorb higher levels of P compared to plants that were not infected. High P uptake by MVA-infected plants is caused by MVA hyphae which secrete phosphatase enzymes so that P bound in the soil will be dissolved and available to plants. According to Musfal (2010) and Musafa *et al.* (2017), the application of MVA biological fertilizers can help release and provide nutrients, especially phosphate for plants through the mechanism of root colonization without causing necrosis.

3.4. Percentage of Root Colonization

Analysis of variance resulted that there was no interaction effect (P>0.05) between between the application of biourin fertilizer and MVA biological fertilizer on shallot root colonization. Single factor analysis showed that the concentration of biourin treatment had no significant effect, while the MVA biological fertilizer dosage treatment had a significant effect on the percentage of plant root colonization.

Table 3. LSD test on the average percentage of shallot root colonization due to single factor concentration of cattle biourin and MVA biofertilizer

Treatment	Root colonization (%)
Biourin concentration (ml/L water):	
10	30,21 ± 23,13 [a]
20	35,76 ± 27,32 [a]
30	41,37 ± 33,14 [a]
40	47,69 ± 39,67 [a]
MVA dose (g/plant):	
0	23,71 ± 11,81 [d]
10	30,64 ± 19,64 [c]
20	43,61 ± 31,02 [b]
30	57,07 ± 39,95 [a]

Note: Numbers followed by the same letters in the same column are not significantly different according to the LSD test at the 5% level. The number followed by ± is the standard deviation.

The LSD test results in Table 3 show that there is a significant difference between each single factor treatment. The treatment of biourin concentrations did not show a significant difference to the percentage of shallot root colonization. Increasing the concentration of bovine biourin from 10 ml/L water to 40 ml/L water did not show a significant difference in the percentage of plant root colonization. The average percentage of plant root colonization ranged from 30.21% - 47.68%. This indicates the role of biourin fertilizer which contains indigenous microbes which can help infect the roots of shallot plants.

Treatment of MVA biological fertilizer doses, showed differences in the percentage of plant root colonization. The lowest percentage of root colonization was achieved in the treatment without MVA, with a root colonization percentage of 30.64%. The presence of colonization on plant roots even without the application of MVA, indicates that there are also indigenous mycorrhizae in the planting area that can infect the roots of shallot plants. This is in line with the research of Matheus & Kantur (2022) stated that treatment without MVA at different organic matter sources showed MVA infection in corn roots.

Increasing the MVA dose to 30 g/plant markedly increased the percentage of colonization by 57.07% and was significantly different from other treatments. There was an increase in the percentage of colonization at high MVA doses, indicating that the MVA used could grow well in experimental field conditions, so that it could associate with the roots of its host plants. Farida & Chozin (2015) stated that increasing MVA doses would increase the percentage of root infection. The more roots that are infected, the greater the level of absorption of nutrients, especially in nutrient-poor soils. The same result was reported by Utomo *et al*. (2017) that the high or low percentage of MVA infection in the roots of corn plants is influenced by the amount of MVA and fertilizers applied.

Research by Wicaksono *et al*. (2014) and Hazra *et al*. (2021) showed that the application of mycorrhizae had a very significant effect on root infection of garlic plants, namely the application of mycorrhizae at SP-36 fertilizer dose of 50 kg/ha had the highest colonization rate of 46.67%. According to Baptista *et al*. (2011), the process of root colonization is divided into 4 stages, namely before infection, penetration of hyphae in plant roots, hyphae grow and develop in root cells, and finally mycorrhiza will help absorb nutrients and water for the host plant. The results showed that the roots of plants that were applied MVA colonized the roots which were characterized by the presence of typical endomycorrhizal structures such as internal hyphae, vesicles, arbuscules or external hyphae; whereas on plant roots without mycorrhizae there was no visible colonization of plant roots.

3.5. Shallot Yield

The results of the analysis of variance showed that the application of bovine biourin fertilizer and MVA biofertilizer had a very significant effect ($P<0.01$) on the shallot yield component in vertisol soils, but the interaction between the two factors had no significant effect. Single factor analysis showed that the concentration of bovine biourin fertilizer and the dose of MVA biofertilizer had a significant effect on the shallot yield component. The components of shallot yield measured in this study included: number of tubers per clump, tuber diameter, tuber weight per plant, and tuber yield per plot. The results of the BNT test for the effect of treatment on the shallot yield components are presented in Table 4.

Table 4. LSD test of the effect of single factor concentration of cattle biourin and MVA biofertilizer on the shallot yield

Treatment	Tuber number per clump	Tuber diameter (cm)	Tuber weight (g)	Shallot yield (kg/m^2)
Biourin concentration (ml/L water):				
10	5.73 ± 4.48 [c]	2.74 ± 2.25 [c]	4.00 ± 3.52 [c]	1.12 ± 0.90 [c]
20	7.01 ± 5.76 [b]	3.49 ± 3.00 [b]	4.37 ± 3.88 [b]	1.49 ± 1.27 [b]
30	8.51 ± 7.27 [a]	3.70 ± 3.20 [a]	5.01 ± 4.53 [a]	1.58 ± 1.35 [a]
40	8.08 ± 6.84 [a]	3.86 ± 3.36 [a]	4.95 ± 4.47 [a]	1.60 ± 1.37 [a]
MVA dose (g/plant):				
0	4.85 ± 2.97 [d]	2.46 ± 1.56 [d]	3.86 ± 3.23 [d]	1.05 ± 0.74 [d]
10	6.99 ± 5.11 [c]	2.95 ± 2.05 [c]	4.22 ± 3.59 [c]	1.41 ± 1.10 [c]
20	8.29 ± 6.41 [b]	3.96 ± 3.06 [b]	4.96 ± 4.33 [b]	1.52 ± 1.21 [b]
30	9.19 ± 7.31 [a]	4.41 ± 3.51 [a]	5.20 ± 4.57 [a]	1.81 ± 1.50 [a]

Note: Numbers followed by the same letters in the same column are not significantly different according to the LSD test at the 5% level. The number followed by ± is the standard deviation.

The LSD test results (Table 4) showed that the concentration of bovine biourin and MVA doses showed different components of shallot yield. The highest onion yield components were achieved at a biourin concentration of 40 ml/L water and a biourin concentration of 30 ml/L water. This shows that with a high concentration of biourin can provide the nutrients needed by plants in the growth and development of tubers. High fertilizer concentrations allow more nutrients to be available than low concentrations.

The increase in shallot yield components in the treatment of high biourin concentrations indicates that biourin fertilizer contains many and complete nutrients, especially nutrients N, P and K and other micro-nutrients which are needed by shallot plants. Shallot plants require N nutrients for vegetative growth, while P and K nutrients are needed for generative growth so that plants can produce optimally. Apart from containing nutrients, biourin fertilizer also contains indigenous microbes which can increase the availability of nutrients for plants. Indigenous microbes in biourin will play a role in degrading organic matter into organic compounds in the form of nutrients available to plants (Rao, 1994; Nasahi, 2010). Liquid organic fertilizer from biourin also contains certain hormones that can stimulate plant growth and development and contain more N and K nutrients, compared to solid cow manure (Aisyah *et al*., 2011).

Application of MVA biofertilizer with doses of 0, 10, 20 and 30 g/plant, showed different components of shallot yield. Increasing the dose of MVA fertilizer significantly increased the components of shallot yield, including: number of tubers per plant, tuber diameter (cm), tuber weight (g), and dry shallot yield (kg/m^2). The lowest yield component was obtained in the treatment without MVA (0 g/plant). The best shallot yield component was obtained at the MVA dose of 30 g/plant, significantly different from other MVA doses.

The increase in the yield component due to the application of high doses of MVA biological fertilizer (30 g/plant), indicates a role of MVA in the root zone through the activity of the resulting hyphae, which will directly increase soil aggregation which will make it easier for plant roots to absorb nutrients and water in the soil. The role of MVA biofertilizer will be more optimal in soil conditions that lack P, such as in vertisols. In conditions of low nutrient availability, the effect of MVA on nutrient uptake is high, because external hyphae can absorb nutrients that far enough from plant roots. According to Swift (2004) in soils that experience phosphorus deficiency, mycorrhizal symbiosis on plant roots will be more beneficial. These results also indicate that mycorrhizal plants can absorb phosphorus nutrients not only from the given P fertilizer, but also from the soil media and organic matter given, so that the efficiency becomes higher. Research by Hazra *et al*. (2021), have proven that shallot plants grown on Inceptisol soil and applied mycorrhizae were able to experience an increase in dry tuber weight per plot of 19.5% compared to plants without mycorrhiza. The application of mycorrhiza 20-30 g/plant is also known to be able to increase the bulb weight per shallot plant planted with intermittent irrigation techniques (Saleh & Atmaja, 2017). The same thing was also proven by the research of Yoanma *et al*. (2022) on ultisol soil, concluded that the application of 80 g/pot biochar and 1.6 g/pot NPK fertilization significantly increased the average weight of fresh stover to 120.54 g/pot, 14 tubers with average diameter of 2.05 cm, and weight of air-dried tubers (70.17 g/pot).

4. CONCLUSIONS

The concentration of biourin fertilizer and the dose of MVA tested on shallots in vertisol significantly affected the dynamics of available P in the soil from the first month to the third month after planting. Application of biourin fertilizer at a concentration of 30 ml/L water markedly increased P absorption by 15.07% and increased shallot yield by 41.07% compared to a concentration of 10 ml/L water. The best application of MVA biofertilizer in vertisols was achieved at a dose of 30 g/plant that was able to increase plant nutrient P uptake by 152% and increase shallot yield by 72.38% as compared to that without MVA.

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